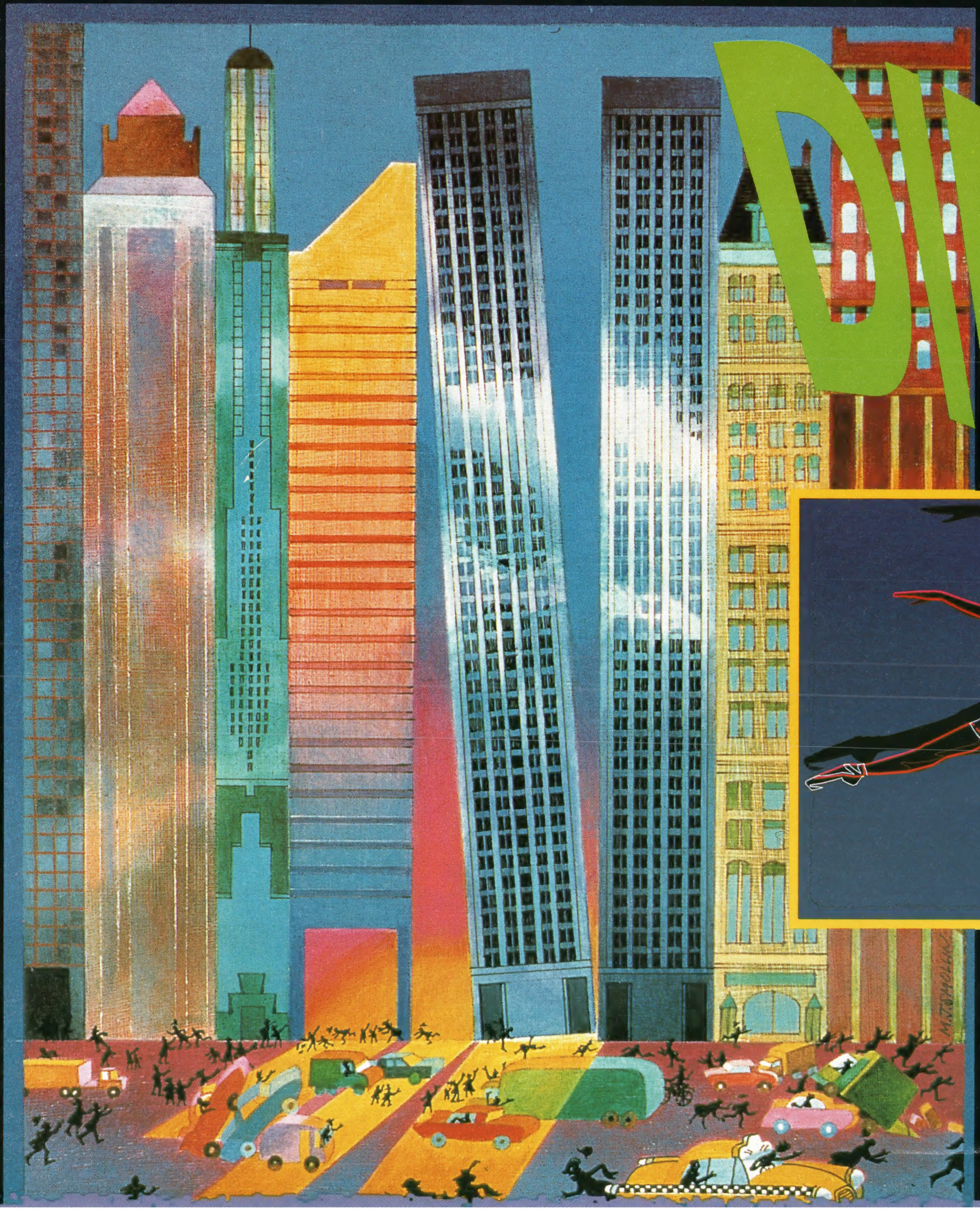
Q NEW CONCEPTS Q DETONOGRAPHS Q COMPUTER ART

DIFFERENT STROKES



ZEFA

TODAY COMPUTERS, ROBOTS, and lasers are as much a part of the art scene as traditional canvas and paints. Techno-artists are even harnessing the power of modern plastic explosives to fuse and mould metal sculptures.

Artist Bryan Rogers is planning to release 64 tiny floating figures in the waters around Hawaii. They are solar powered and microprocessor controlled to generate patterns of electronic tones.

This is part of a project that he started in 1980 when he released 100 free-floating modules in the San Francisco Bay area. These, however, did not have the sound generating equipment built in.

Self-propelled

In the next phase of the project he plans to launch 16 modules that will be capable of both sending and receiving information. Then he plans to build a self-propelled, solar-powered unit capable of navigating itself completely around the world.

***Using computers** to produce sophisticated graphics is a major new art form. Pictures and colours never dreamt of before can be created and manipulated and, once on the computer, it is an easy step to animate a drawing (inset).*

Rogers also makes sculptures from umbrellas that are periodically opened and closed by a pneumatic system and an electromechanical timer. He came to notoriety in 1977 with a sculpture that randomly stabbed a harpoon into an aquarium where a goldfish was swimming.

'Chatter, chatter'

Jim Jenkins specializes in making moving sculptures from TV sets. He used four to make a bucking bronco. Jonathan Borofsky made *20 Chattering Men* in 1984. Twenty life-size aluminium figures were fitted with small speakers which muttered the words 'chatter, chatter, chatter'.

Painting with sound is an innovation of artist Alain Husson Dumoutier. He wired up 400 lights behind a painted plexiglass screen. The lighting circuits are computer-controlled and voice-activated. Different tones switch on different coloured lights.

Daudier/Jerrican

Rex Features Ltd

David Hockney *sent a drawing by fax from California, USA, to his native Bradford, UK.*

Some artists use their art to make a satirical attack on science. When a Los Angeles museum dropped and broke a unique 'lifting body' aircraft donated by NASA, Dave Quick produced *Mishap at the California Museum of Science and Industry*. In Quick's version, a rubber chicken falls on 'Tom Edison's first lightbulb' and 'the only intact dinosaur egg ever discovered'. And in *Little Nuke*, lights flash, dials spin, LEDs count furiously, alarms sound, a rubber chicken lays a model nuclear bomb and the sign 'Nuclear fission – evacuate' flashes.

Bomb art

Salvador Dali once exploded a bomb filled with nails against a copper plate, producing a striking but random pattern. Many other artists have used explosives in their work, but generally the results have been uncontrolled.

Now, however, Evelyn Rosenberg, a sculptor working at the New Mexico Institute of Mining and Technology, has harnessed the energy of high explosives to create preplanned bas-reliefs (shallow carvings set against a flat background) in brass, copper, and stainless steel.

Blast problems

Rosenberg's first attempts proved disappointing. Sometimes the explosives ripped holes in the metal or hurled materials through the air. After about 80 attempts, though, she was able to gauge the thickness of the metal and the strength of the blast so as to create attractive sculptures, which she calls 'detonographs'.

To produce a detonograph, Rosenberg first sculpts a bas-relief in plaster to form a mould. She covers the mould with a 100 x 130-cm panel of brass, copper, or stainless steel. Then she places thin coloured metallic foils, together with various objects such as cloth, string, or leaves, on top of the metal she aims to sculpt.

Plastic explosive

At a blast site in Socorro, New Mexico, a technician covers the whole design with a layer of C-1 Detasheet, a plastic explosive manufactured by the Du Pont company. C-1 Detasheet consists of pentaerythritol tetranitrate

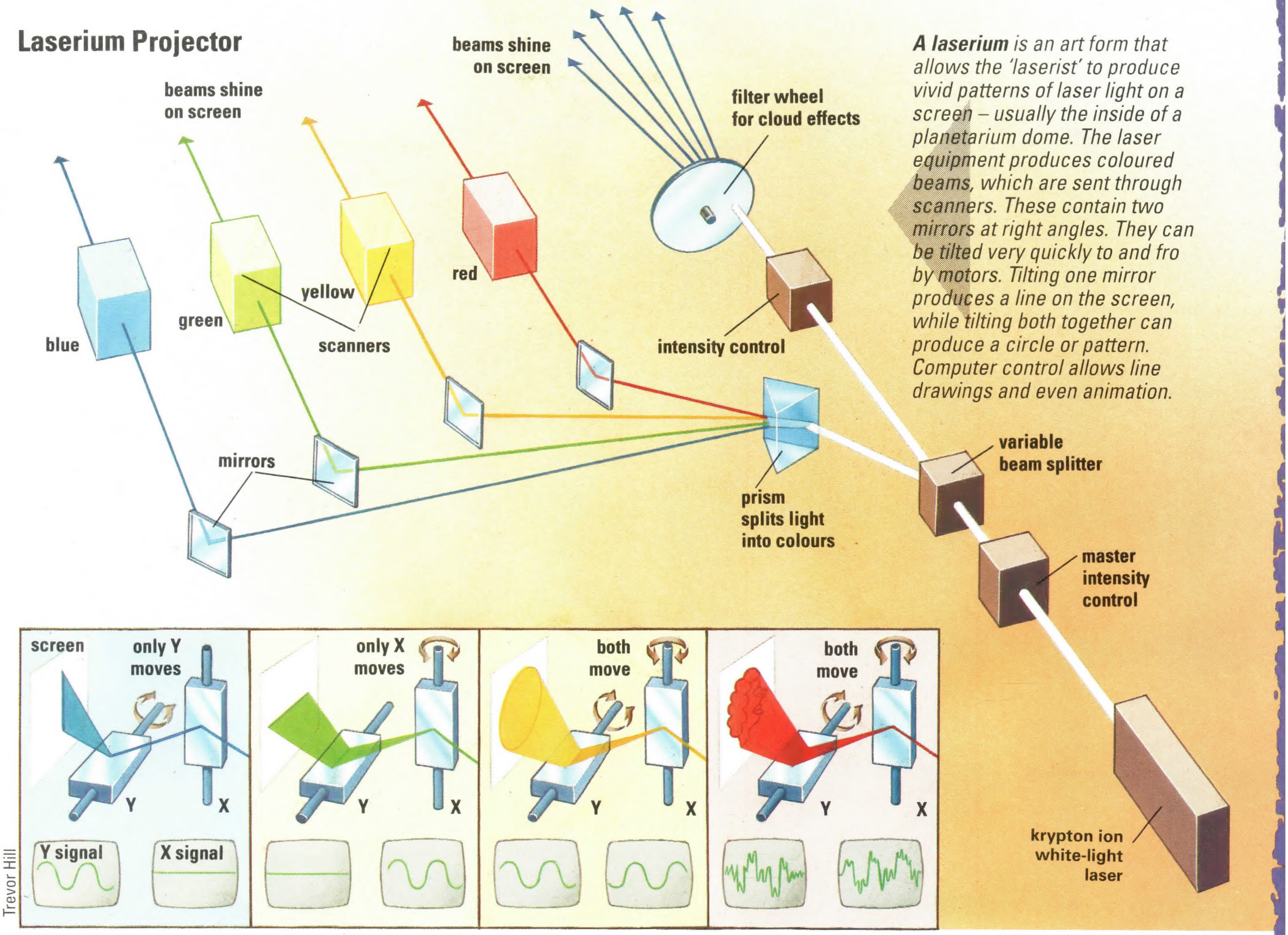
NEW DIMENSIONS FOR 3-D ART

A hologram of an object is made using two beams of laser light. One beam is bounced off the object on to a photographic film. The other beam travels directly to the film where it interferes with the first beam (below). The resulting interference pattern, when viewed properly, creates a solid image of the original object.

Many examples of holographic art already exist – like this holographic champagne glass, which is married to a real broken glass (left). In the future, however, this technique will be taken much further. It will be possible, for instance, to create fantastic scenes on a computer graphics screen and then generate a holographic image directly, using the information stored in the computer's memory.

Philippe Plailly/Science Photo Library

Gamma/Frank Spooner Pictures



Trevor Hill

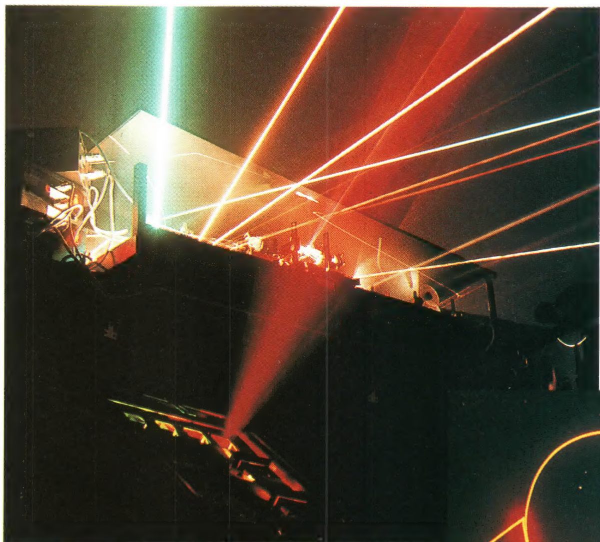
***A laserium** is an art form that allows the 'laserist' to produce vivid patterns of laser light on a screen – usually the inside of a planetarium dome. The laser equipment produces coloured beams, which are sent through scanners. These contain two mirrors at right angles. They can be tilted very quickly to and fro by motors. Tilting one mirror produces a line on the screen, while tilting both together can produce a circle or pattern. Computer control allows line drawings and even animation.*

and cellulose nitrate with a plastic binder. It is constructed to detonate very fast to give an even blast.

Fireball

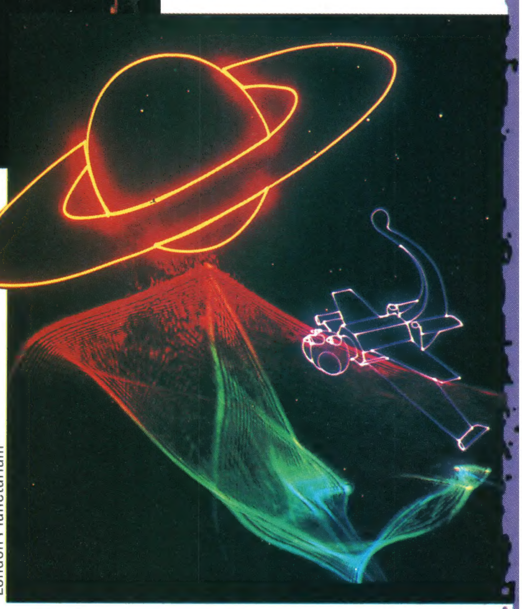
As soon as the technician detonates this explosive sandwich, a 6-metre-wide fireball erupts from it. The explosion drives the metal panel into the mould in the instant before the mould shatters. At the same time, the tremendous pressure of the explosion clads the panel with the metal foils, adding regions of colour. The cloth, string and leaves are driven into the panel at a speed of 6,800 m/s and provide texture before disintegrating in the heat of the flames. Then Rosenberg cleans and polishes the panel to complete the artwork.

Other artists use a monitor screen

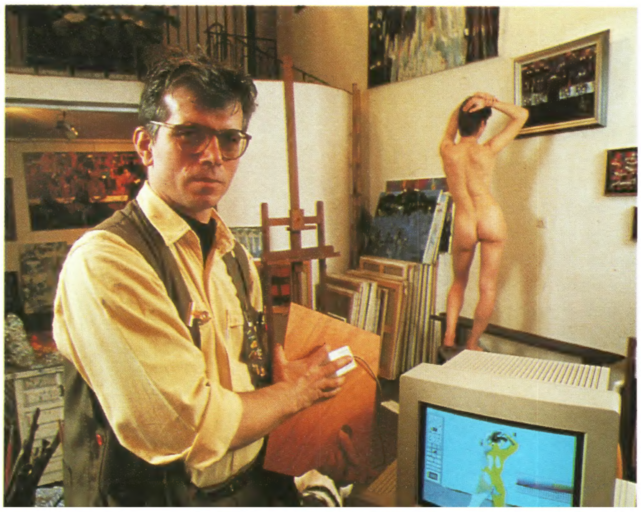


Ray Duns

***The beams** of a laserium machine flicker across the screen rapidly as the scanning mirrors inside tilt under computer control. By scanning the same path repeatedly, a single beam turns into a line. The artist can 'draw' cartoons (below), which can be animated to music.*



London Planetarium



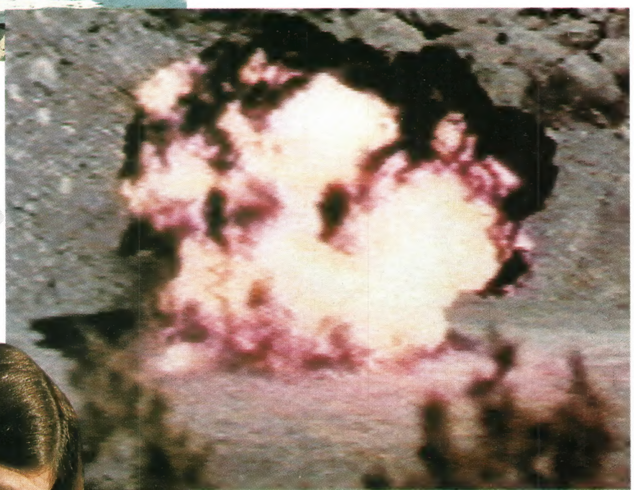
Gamma/Frank Spo Pictures

***Traditional studies** of the nude body can be given a new twist by painting on the computer rather than on a canvas. A number of devices have been developed to input the artist's work. Here a mouse is being used. The colours and shapes can be modified later.*

in place of a canvas and a light-pen instead of a paintbrush. Along with a computer, these can be used to create fantastic, flowing images of things never even imagined before. Special software breaks the screen down into thousands of tiny picture elements, or pixels, and then controls the colour and brightness of each pixel according to the artist's wishes.

Modern computer graphics programs handle everything from simple line-drawing to sophisticated shading, texturing and transparency effects. The artist uses a light-pen, electronic stylus, or mouse, to pick from a menu of commands or to sketch directly on to the screen.

A piece of computer art might begin with the construction of a simple 'wireframe' drawing of, for example, a butterfly. Thousands of tiny polygons, or flat, many-sided shapes, are then joined to this basic framework like a skin. The artist can select the precise hue of each facet from a palette of up to 16 million different colours offered by the computer. Other software enables precise control over the shading so that it is possible to create the illusion of solid surfaces and smooth curves. In the next stage, the artist adds texture to the various surfaces. The butterfly's wings can be made to seem transparent while the eyes can be given a mirror-like quality. Finally, the artist can call upon digitized data from actual scientific drawings to add a final touch of realism to the picture.



Oren Rosenberg

***Detonograph** artist Evelyn Rosenberg carefully prepares the mould (above). This is covered with a sheet of high explosive. The resulting bas-relief (below) is cleaned and polished.*

Zoom in

One of the great strengths of the computer is its ability to make rapid changes. If the artist, for instance, is not satisfied with a particular colour scheme or some aspect of the texture, then this can be altered in a matter of seconds. Other options allow the artist to zoom in on any part of the image or to rotate it in three dimensions. And, by creating a series of images, each slightly different from the one before, the computer can make realistic animations possible.

But art does not have to be confined to the screen. Imagine a house in which the walls can instantly change colour to match your curtains or your mood. This may soon be possible thanks to electrochromatic materials.

When an electric current passes through certain substances it alters their colour. This is because the electrons making up the current become attached to the molecules of the electrochromatic chemical, so altering the wavelength at which it gives off light. If the current is reversed, the electrons are driven out, causing the colour to change back again.

Moving paintings

Walls coated with electrochromatic material could be changed from red to green to blue by, for example, simply turning a knob that altered the current running through them. Patterns can also be created. In the same way, it may not be long before there are electrochromatic advertising posters in underground stations. In this new medium, artists could even create moving paintings.

Total Group

Just amazing!

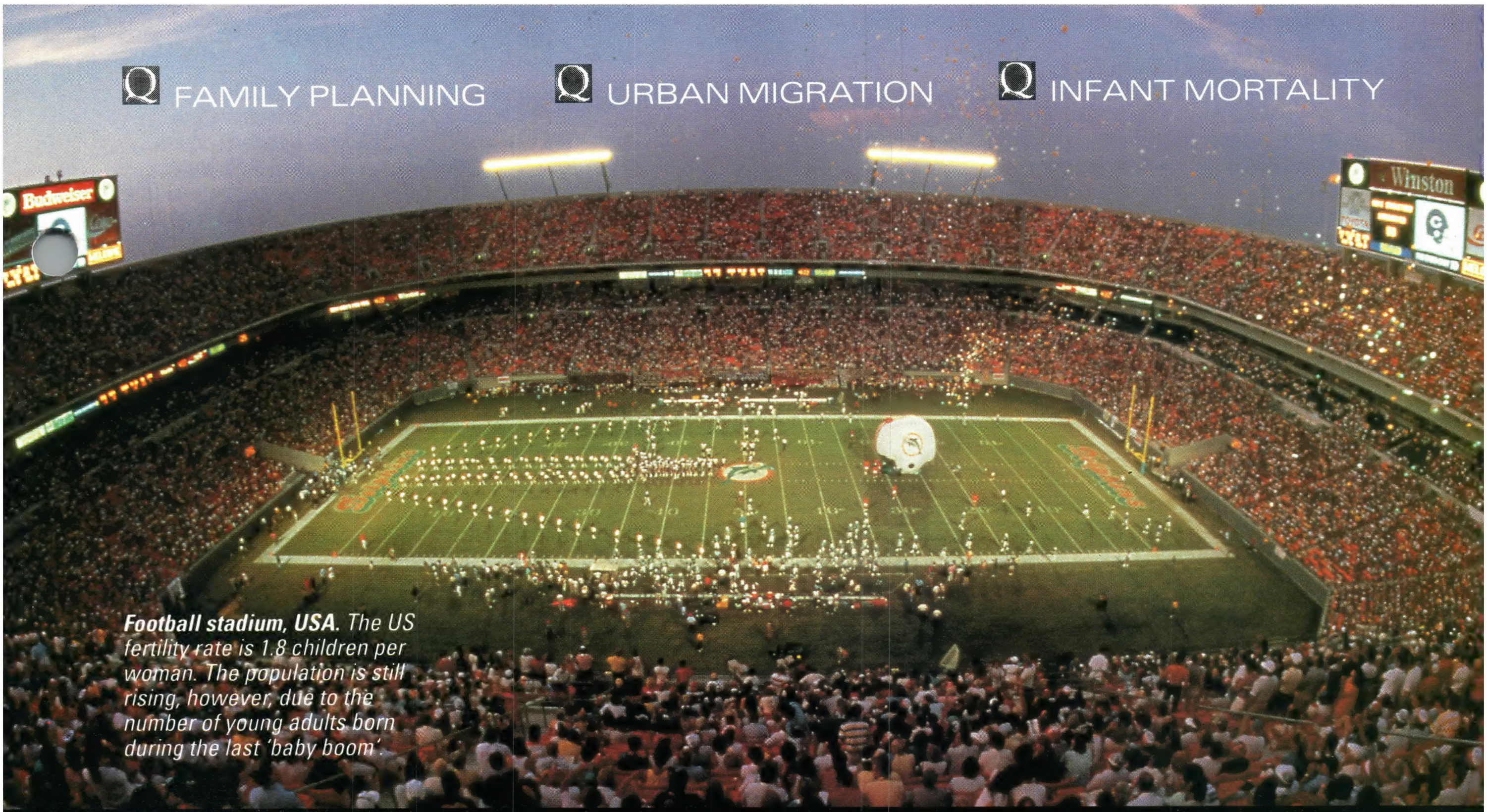
BIG IDEAS

IN 1983, CHRISTO CREATED THE WORLD'S LARGEST PIECE OF ART BY WRAPPING 11 ISLANDS OFF FLORIDA, USA, IN 603,000 SQUARE METRES OF PINK PLASTIC SHEETING.

Paul Raymonde

PUSH-BUTTON TEXTILE DESIGN

Textile designers are now using desktop computers to create the latest fashions. Designers can turn yarn into fabric and sketch a garment from the fabric without even leaving their computer workstations. As a result, a design process that previously took weeks or months can be completed in less than 24 hours. The images by colour monitors, or reproduced on colour printers, are so realistic that buyers from department stores are prepared to commit millions to a new range of clothes after simply seeing the screen displays or printouts. In the United States, AVL Looms of California, has gone one step further. When a design has been perfected on the computer, a second set of programs controls the loom that turns the design into a finished garment.



Football stadium, USA. *The US fertility rate is 1.8 children per woman. The population is still rising, however, due to the number of young adults born during the last 'baby boom'.*

Gamma/Frank Spooner Pictures

THE BIG SQUEEZE

WHEN THE 20TH CENTURY started there were just two billion people on Earth. By the end of the century there will be more than six billion, and the population will go on climbing.

It is estimated that the population will reach its peak somewhere in the latter half of next century. How many people there will be on Earth then is not possible to predict accurately. It could be as few as 8 billion, it could be as many as 14 billion.

Family planning

The lower projection of eight billion assumes that in the next two decades the number of women using family planning in the developing world will increase to 71 per cent, which is the level in industrialized countries. Worldwide, the percentage of couples using contraceptives in the reproductive age range is 45 per cent. This figure is heavily influenced upward by the success of China's family planning programme. Excluding China the percentage worldwide is only 30 per cent.

The growth of population is not uniform across the world. The average population growth is 1.8 per cent, enough to double today's population in 39 years. But Italy's birth rate is just 1 per cent. Britain's is 1.4 per cent and the only country in Western Europe that is producing enough native-born children to replace its current population is Ireland.

Age concern

In the rest of Europe and North America, the availability of contraception has allowed people to choose to have less children. This declining birthrate itself causes an economic problem in these countries. More people are living well into retirement, but the number of active young people who are working to support them is declining. In some countries it is predicted that with this 'greying' population the social services may soon run out of money to provide for pensions and medical care.

In developing countries the

Andrew McLenaghan/Science Photo Library

Hong Kong *ranks third in the list of the most densely populated countries and colonies in the world. Population is* ***5,761,000*** *in an area of only 1,037 sq kms.*

Ciba-Geigy Ltd

World food supplies *depend on more productive agriculture. The application of scientific knowledge produces high yielding seeds and improved plants.*

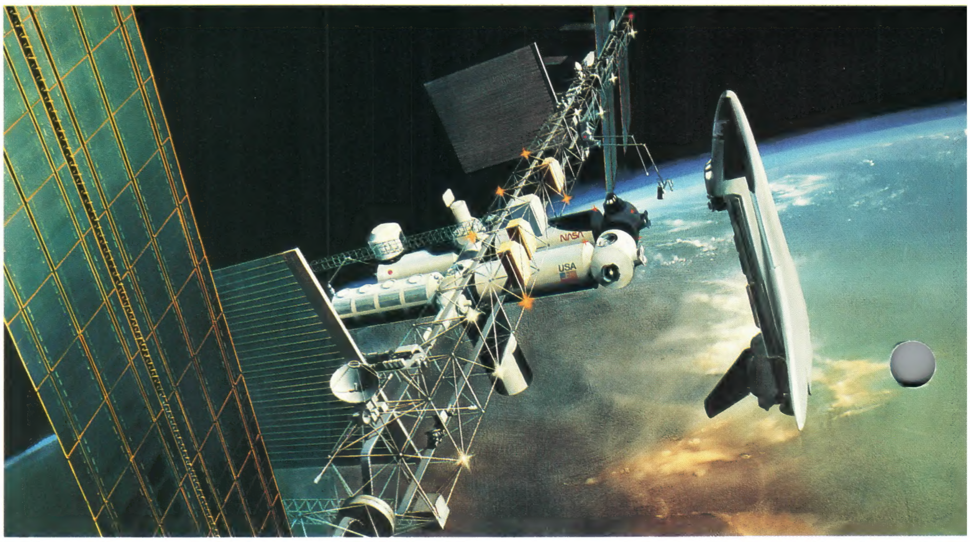
Homes in Space? *This US Space station is under development and is due for permanent occupancy in orbit by the late-1990's. Scientific and technical research will be carried out in the gravity-free environment.*

Paul Raymonde

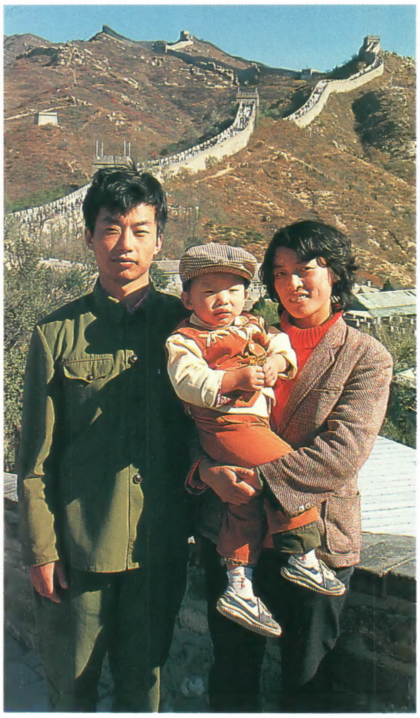
especially in developing countries, have few options outside marriage and motherhood. Economic and social self-determination for women: education, health, equal access to land and rewarding employment plus control over their fertility help widen women's opportunities and reduce their dependence on children for status and support.

Education

Women with wage-paying jobs tend to have fewer children. Studies also show that women who have completed primary school have fewer children than those with no education. They delay getting married, learn more easily about contraception and also suffer fewer infant deaths – high infant mortality is associated with high birth rate. Women's deaths as a result of childbearing are also much higher for those countries with a high birth rate. More women in India die as a result of pregnancy and childbirth in one day than in the developed countries in one month.



NASA



Gavin Hellier/Robert Harding Picture Library

China's one child per couple *policy, in the world's most populated country, is an attempt to deal with an annual rate of increase of 12.8 million people.*

One child policy

In China, people have been encouraged to have only one child and, in 20 years, the birth rate has dropped from 3.4 per cent to 2.1 per cent. But recently, the Chinese government have realized that this policy is unrealistic and women over 30 are now allowed to have a second child if their first child is a girl. This means that China will overrun its end-of-the-century population target of 1.2 billion by some 50 to 80 million.

India started its family planning programme in 1952 and has reduced its birth rate to 2.1 per cent. This still means that India's population will double in just 32 years. Although the programme was in many ways a success, the decline in mortality and the country's extreme poverty make further progress difficult.

Since the population of India and China represent 37 per cent of the world's total, any upward revision of their fertility rates has a major impact on projected world population.

OVERCROWDING

Scientists have discovered that over-population has physical effects – in their own laboratories. Recent surveys of the well-being of animals kept in laboratories for experiments has revealed that keeping animals in overcrowded conditions creates all sorts of stress-related problems.

As well as behavioural difficulties, many rats were discovered to have high levels of hormones in their bodies, stimulated by stress, which made them useless when testing for toxins. In a comparison between isolated mice and overcrowded mice, the overcrowded mice were observably less healthy and were more vulnerable to gut parasites.

Macaques – a type of monkey often used in laboratories – showed a breakdown in the immune system.

Q ETHANOL

Q GASOHOL

Q HYDROGEN

***Energy and pace** are essential elements of Formula One racing, especially at the Indianapolis 500 but the cars use methanol rather than pump petrol.*

Robert Brown/Allsport

NEW FUELS

CARS THAT RUN ON PETROL may soon be a thing of the past. In an effort to cut drastically the amount of pollution caused by cars, manufacturers are turning to alternative fuels that burn efficiently but cleanly.

At present, cars, trucks, buses and other road vehicles emit huge quantities of dangerous gases. Some of these, such as carbon monoxide and ozone, are a direct health threat to people living in large cities, where car fumes tend to be most concentrated.

Other waste gases, such as carbon dioxide, contribute to global warming through the greenhouse effect, while still others, including the oxides of sulphur and nitrogen, result in acid rain. The lead added to petrol to improve combustion causes brain damage.

To protect the environment, increasingly strong laws are being passed in Europe and North America that will force manufacturers to produce cars with cleaner exhausts. They have sent the car-makers hurrying to their computers and laboratories in a race to develop effective new fuels, together with new engines that can use them.

Grain alcohol

Alcohol may not seem the likeliest substance to replace petrol, but in Brazil hundreds of thousands of cars are already running on ethanol – the type of alcohol found in beer and wine. Ethanol, or grain alcohol, is obtained by fermenting crops such as sugar cane, corn and sorghum which are grown for this purpose all across Brazil.

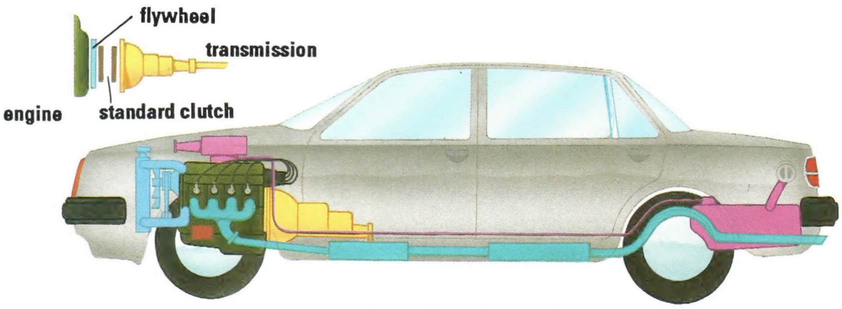
Like the chemicals in ordinary petrol, ethanol is a hydrocarbon. In other words, its molecules contain carbon and hydrogen atoms linked together. But there are fewer of these atomic links in ethanol than in petrol, so, when ethanol burns, it breaks down more easily and gives off smaller quantities of pollutants. Ethanol's main disadvantage is its fairly high cost. A better and cheaper alternative, some experts say, is methanol, or wood alcohol.

Indianapolis 500

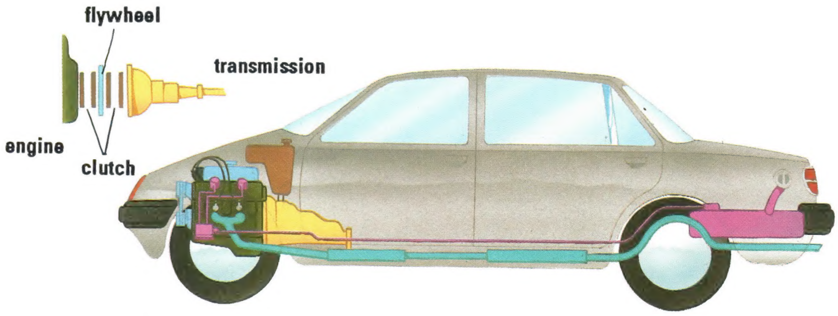
Methanol – the kind of alcohol found in methylated spirit – gives off only about one-tenth the amount of toxic pollutants that petrol does when it burns. It also delivers more power, which explains why all cars taking part in the Indianapolis 500 now have methanol-adapted engines.

Running on pure alcohol is difficult for a car that has been designed to use petrol. But in some countries, such

A methanol-powered *car needs a smaller engine, smaller fuel tanks, smaller exhaust system and smaller cooling system than a petrol-driven car. This means the car, especially the front end, can be trimmer and more aerodynamic. The double-clutch start-stop system shuts off the engine whenever the car slows, saving even more energy.*



Petrol-Driven Car



Methanol-Driven Car

Trevor Hill

WIND-POWERED CARS

The ultimate in pollution-free motoring may be to tap the energy of the Sun or the wind. Experimental vehicles fitted with solar cells have already been tested and have even competed in a race across Australia. But how could a car make use of the wind? One possibility would be to fit a car with rigid sails controlled by microcomputer. Sensors would tell the computer which way the wind was blowing from one second to the next so that the computer could adjust the sails accordingly. Alternatively, the car could be equipped with a wind-turbine that produces enough electricity to maintain cruising speed.

as the US, gasohol – a mixture of 10 per cent alcohol and 90 per cent petroleum – is gaining in popularity. The next step may be to manufacture vehicles that can run efficiently on so-called M85, containing 85 per cent methanol. Finally, when the demand is high enough, manufacturers may produce M100, or 100 per cent methanol-burning cars. An engine built specifically to use methanol could be smaller, lighter and more powerful than a petrol-driven one.

Waste gas

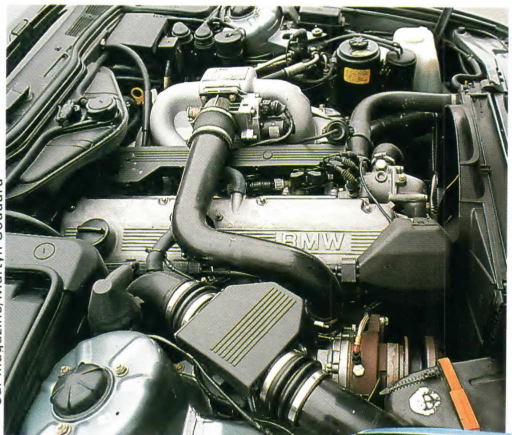
With crude oil supplies expected to run low over the next 50 years, it will be important to develop fuels that come from sources other than oil. Methanol, for instance, could be manufactured from natural gas that is currently vented or burned off at remote oil wells. Alternatively, it could be made from coal, which there are still plentiful supplies of in many locations around the world.

Natural gas itself has been proposed as a car fuel of the future. But it has to be squeezed under a pressure of about 700 to 1,000 kg/cm^2 in the cylinder for it to be useful. This would demand very heavy tanks, which would limit a vehicle's performance and fuel efficiency.

Hydrogen-powered engines are another possibility. However, at the moment, hydrogen is difficult to produce in large amounts and hazardous to store and distribute.

Variable fuels

For now, the best solution seems to lie with 'variable fuel' vehicles: cars that can run on petrol, ethanol, methanol or any combination of the three. Such cars have an optical sensor in the fuel tank, which is connected to a control module that makes the necessary adjustments to the engine.



Car magazine/Martyn Goddard

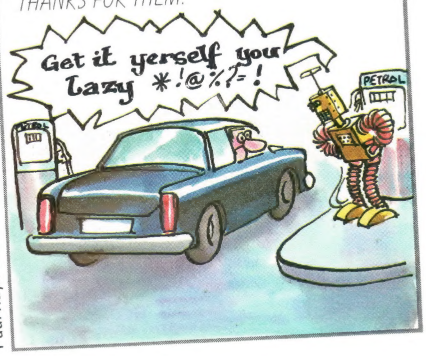
Car engines *can be modified to take hydrogen fuel. It is efficient, produced easily from water and non-polluting, but there are problems. Hydrogen has to be stored as a liquid at low temperatures, is very volatile and potentially explosive. The slightest spill could be dangerous. Prototypes (below) have to have much larger fuel tanks too. But hydrogen is probably the fuel of the future if ways can be found to store and distribute it safely.*

INS/Jerrican

Just amazing!

ROBO-SLOP

FOR PEOPLE WHO ARE TOO LAZY TO GET OUT OF THEIR CARS, A SWEDISH COMPANY HAS DEVELOPED A ROBOT WHICH WILL FILL UP THEIR PETROL THANKS FOR THEM.



Paul Raymonde

SAVE IT!

Stockholm Energi

AT THE PRESENT RATE, the world reserves of coal will start to run out in about the year 2220, natural gas in 2050 and oil in 2020. Even supplies of nuclear fuel are not unlimited.

Most electricity is generated by turbines driven by steam that is produced by coal, oil or nuclear fuel. But the problem is that at least 10 per cent of the heat used to make steam is wasted, while only 30 per cent of a station's steam energy is converted into electricity.

Waste heat

A combined heat and power (CHP) plant can exploit this normally wasted energy, by operating in an unusual way. A CHP plant generates less electricity than a conventional power station, but the waste water is at a much higher temperature. This is then pumped along large pipes underground to blocks of flats and factories nearby. Here it is used for room and workspace heating and as an inexhaustible hot water supply.

__Combined heat__ and power plants are used successfully in Scandinavia. They produce electricity and warm water, which is pumped through pipes (right) to nearby houses.

Stockholm Energi

Overall, CHP plants raise the efficiency of energy production to 70 or 80 per cent – compared to some 30 per cent efficiency at an ordinary power station. Even with the added expense of the pipes and pumps needed to carry the hot water, such schemes have proved attractive.

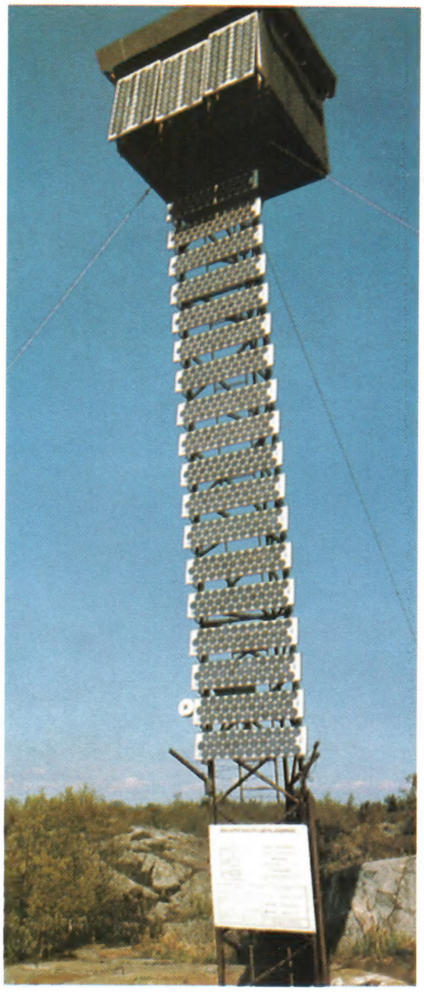
Producing steam at a much higher temperature is the easiest way to boost the heat efficiency of many types of power station. For example, the steam supplied to the turbines of a conventional coal-fired station has a temperature of about 540° C. If this could be raised to 1,200° C, the efficiency with which heat energy is converted to electricity could theoretically be much greater. New materials that could withstand such temperatures will be needed for the turbines, heat-transfer units and piping.

Progress in materials technology now makes this a real possibility for the near future. Ceramics such as silicon nitride and silicon carbide are stable for long periods at temperatures exceeding 1,200° C. They may soon be used to make heat-resistant turbine blades. Advanced metals are another possibility. The high operating temperature and heat efficiency of nickel aluminide – a so-called intermetallic alloy – might make it very useful for future turbine parts or super-hot, pressurized steam piping.

THE GAS GUZZLER

The National Motor Museum, Beaulieu

Oil shortages and soaring prices at the petrol pumps in the early 1970s led to a major rethink of car design – especially in the United States where huge, gas-guzzling cars were once all the rage. Quickly, car manufacturers began to look at ways to improve fuel economy. This involved drastically reducing body weight, making the shape of the car more aerodynamic, and cutting engine size while boosting performance. Most recently, computers have taken on a major role in the car industry. Huge, supercomputers are used to model every aspect of a new automobile design from simulated wind-tunnel tests to detailed engine analysis. At the same time, microcomputers are being used increasingly to monitor and control the engine to achieve maximum efficiency.



***This small tower** of solar panels provides enough electricity for one family living on a remote island in Sweden. The electricity made during the day is saved in batteries for use at night.*

Alf Linderhein/Vattenfall

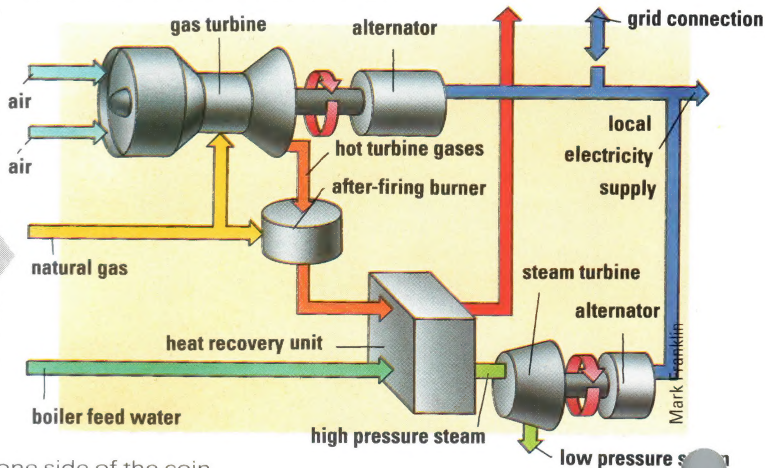
Fuel cells

Fuel cells provide the best opportunity for overall efficiency. Phosphoric acid fuel cells rival CHP plants in efficiency, and experimental models in Japan and the US can achieve almost 90 per cent efficiency overall. They work by direct chemical reaction between hydrogen or methane and oxygen, so no polluting nitrogen oxides and less carbon dioxide are produced.

Producing energy efficiently is one side of the coin, using it efficiently is the other. New homes and factories are increasingly being designed with energy conservation in mind. Better insulation, double-glazing and other improvements in building materials help minimize the amount of heat being lost in winter. They also prevent excessive outside heat in summer from getting in. Careful positioning of large windows on the south side of buildings allows solar energy to be captured for space heating, while active solar panels supply energy for heating and making hot-water.

In the more distant future, 'smart' materials will alter their properties as external conditions change. A smart insulator coating the roof and outside walls could respond to cooler weather by letting less heat escape. In warmer weather, it would let the right amount of heat enter.

Combined Heat and Power Plant



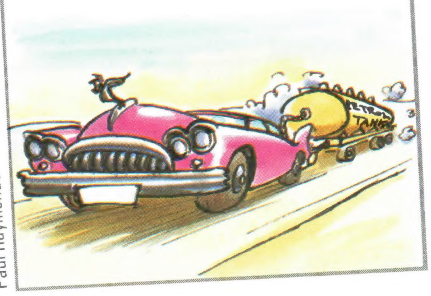
A combined cycle CHP plant uses both a gas turbine and its exhaust heat powering a steam turbine to generate electricity. Heat in the exhaust steam from the steam turbine is not wasted either. It can be used for central heating in local buildings.

Mark Franklin

Just amazing!

GAS GUZZLERS

THE AVERAGE AMERICAN GETS THROUGH 4,500 LITRES – THAT'S 25 BARRELS – OF OIL A YEAR. IF OTHER NATIONS USED AS MUCH AS AMERICA, THE WORLD'S OIL RESERVES WOULD BE USED UP IN EIGHT YEARS.



Paul Raymonde

TRASH POWER

- REFUSE POWER
- PLANT POWER
- NATURAL ENERGY

***An inspector** checks the steam-carrying pipework at a hospital incinerator (right). Waste heat from the incinerator is recycled to provide extra power. Sunflowers (below) may seem an unlikely source of energy, but their oil can be used as fuel.*

Sipa/Rex Features

James Stevenson/Science Photo Library

EVERY YEAR, 250 MILLION tonnes of trash are tossed out by households and companies in America alone. Yet most of that solid waste is still useful. About 11 per cent of it – mostly glass, aluminium, newspaper and plastic – is recycled. The rest is a potentially valuable source of energy.

Energy can be extracted from rubbish in several ways. In some waste power plants, the refuse is simply fed directly into large incinerators and burned. Others pre-treat it to ensure that it burns evenly and efficiently, although this adds to the running costs. The heat is used to make steam to drive a turbine and produce electricity as in a conventional power station.

Careful control of the temperature, burning time and flow of materials in the incinerator is important. In this way, a waste-to-energy plant can generate an average of 500 kilowatt-hours of electricity for every tonne of garbage.

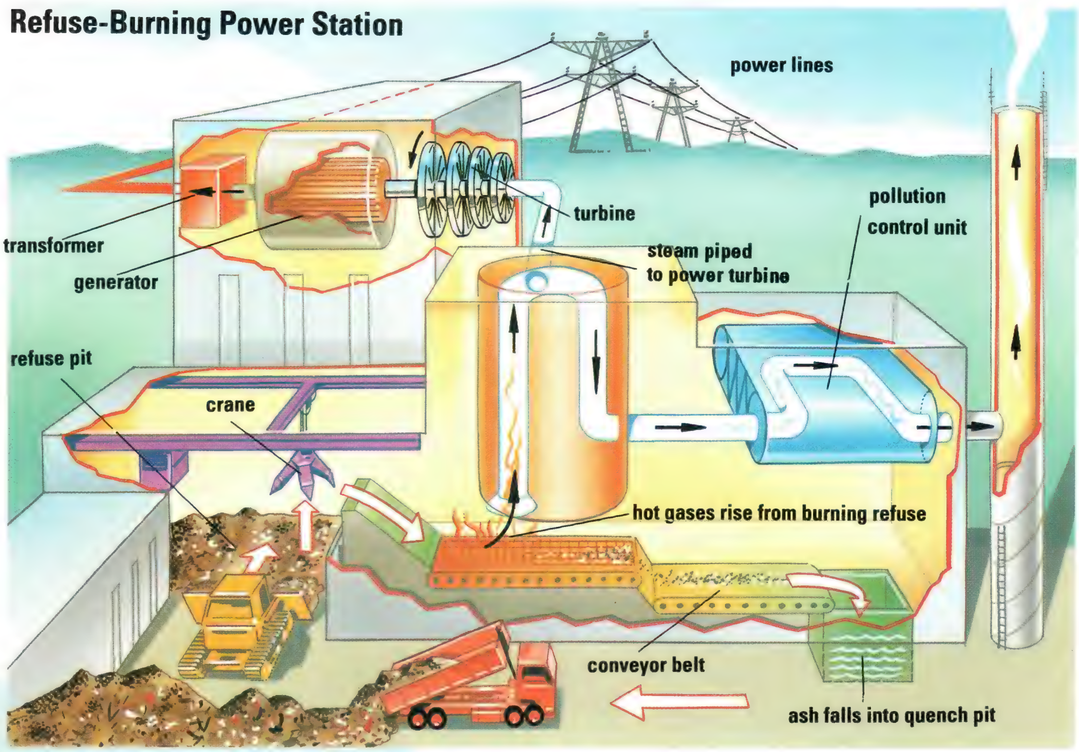
Future prospects

A city the size of Frankfurt, for example, with **650,000** inhabitants, creates more than 150,000 tonnes of rubbish a year. Burning this could provide the city with about a tenth of its heating needs. Similarly, in the USA, waste-to-energy plants may handle as much as 17 per cent of the nation's solid waste by the year 2000.

A different approach is to turn refuse into more convenient forms of fuel. Through pyrolysis, for instance, waste organic matter (household rubbish, wood and agricultural waste like straw) is burned at high temperatures in the absence of oxygen to produce low-grade gas and oil fuels. Alternatively, a process known as liquefaction converts rubbish into liquid fuel by heating it in a solvent with carbon monoxide and a catalyst.

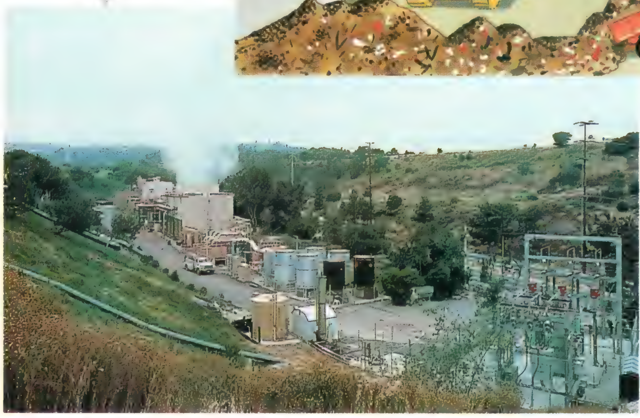
Solid fuel, called refuse-derived fuel (RDF), can also be obtained from waste. The organic portion of the rubbish is separated, shredded, dried and compacted into pellets, briquettes, or logs. These can then be

In a refuse-burning power station, refuse is delivered by lorry and then passed along a conveyor belt to be burnt. The hot gases rising from the burning rubbish heat the water in a boiler, and the steam drives a turbine generator.



Joe Lawrence

This gas recovery *plant in California, USA, uses methane gas released from a waste dump to produce electricity. The gas is collected and then used to produce steam to power a generator.*



Hank Morgan/SPL

burned in solid fuel furnaces to provide about 60 per cent as much heat as an equivalent mass of coal.

Buried in rubbish tips and landfills, plant and animal remains rot slowly in an oxygen-free, or anaerobic, environment. First, the complex organic compounds in paper, animal and vegetable matter break down into sugars and fatty acids. Then these substances decompose to give biogas – a mixture of 40 per cent carbon dioxide and 60 per cent methane.

Normally, the biogas works its way to the surface and escapes into the atmosphere, where it contributes to the global greenhouse effect. However, it can be carried away in pipes and used directly in boilers or kilns or in electrical generation. Over a period of 10 to 15 years, the potential output from one tonne of landfill waste is about 400 cubic metres. When burned, the biogas releases two thirds as much energy as natural gas.

In China, over 7 million family biogas units have already been installed. These use human waste, animal manure and other agricultural waste as their basic fuel and produce gas for cooking. As the dung rots down, the action of bacteria produces biogas. Now, scientists are searching for new types of micro-organisms to improve biogas output. Biogas digestors may eventually produce enough heat and power to supply

Just amazing!

HOT STUFF

EVERY SECOND THE SUN GENERATES 4 MILLION TONNES OF ENERGY AND WILL CONTINUE TO DO SO, IT IS THOUGHT, FOR ANOTHER 5,000 MILLION YEARS.

Paul Raymonde

Plant power

Plants may be used in two different ways to provide energy in the next century. First, specially developed, fast-growing trees and shrubs may be burned to provide energy directly. Second, selected plants may yield fuels such as diesel substitute, which can be used as alternatives to petrol.

In Zimbabwe, for example, oil is already extracted from sunflowers and used to run tractors and other farm machinery. Current plant-derived fuels are not as efficient as petrol or diesel and give off more carbon. However, new plants may be developed in future to overcome these problems.

GEOTHERMAL POWER

Cam[...] School of Mines,Geo Thermal Energy Project

In certain parts of the world, natural, hot, underground water is already being used as a source of energy. Ten per cent of New Zealand's electricity needs, for example, are supplied by this geothermal power.

Exploiting the Earth's natural energy supply is straightforward when it simply involves bringing water to the surface. But in the future, scientists hope to be able to tap the geothermal power stored in dry rocks, even if they lie several kilometres down.

This could be done by pumping cold water down a well into cracks in the hot rocks. Then, after the rocks had heated the water, it would travel to the surface through a second well and could be used to drive turbines to produce electricity in the conventional way.

Irrigation in the Sahara desert needs downstream drainage and provision for overflow. Without these, a concentration of salts make the land infertile.

Tony Stone Photo Library, London

SHIFTING SANDS

IT IS ESTIMATED THAT 100 countries in the Indian Subcontinent, Africa and South America face the problem of desert spread. It is also calculated that in recent years 100 square kilometres of the Earth's land surface have become desert every day.

Desertification is the spread of desert-like conditions in arid or semi-arid areas due to man's influence and climatic change. The speed of change observed at the moment is predominately a result of man's activities with occasional runs of dry years.

Removal of vegetation cover by firewood collection, intensive livestock grazing and over-cultivation leads to water erosion and removal of surface soils by wind. This in turn means that the environment becomes less able to support ever increasing population levels. People then have to struggle more to get food and they strip even more vegetation cover off the surface of the land, making it more likely that it will be eroded or blown away. If a period of low rainfall occurs the process intensifies and eventually the land loses the vegetation cover that binds the surface and retains water when it does rain. The desert then advances into once fertile areas.

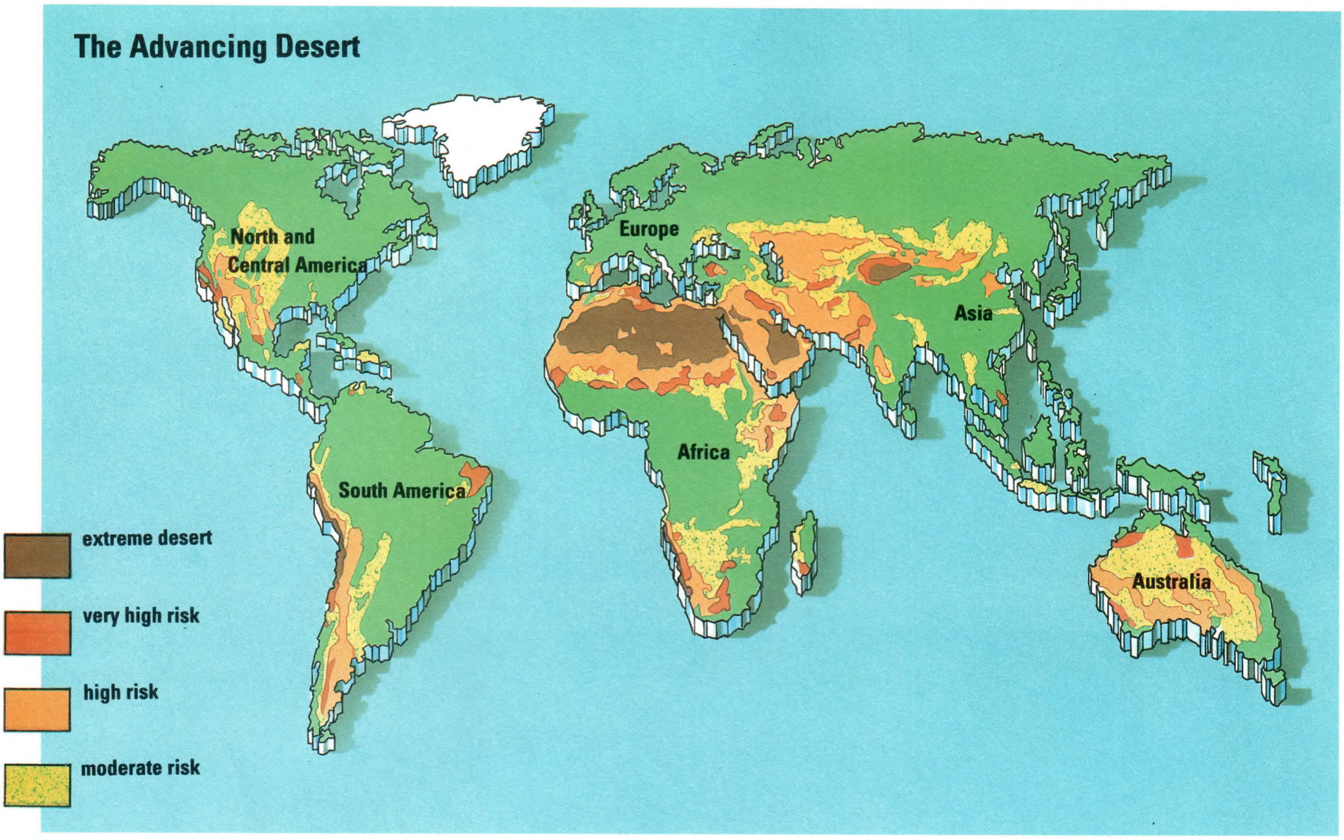
Hutchison Library

***Drought in the Sahel** in the 1970s was combined with an increased demand by livestock for the foliage that provided fuel and also protection for the soil. At least 100,000 people died.*

Continental drift

In the very long term – over millions of years – deserts advance and recede. The mechanisms driving this are continental drift, which is otherwise known as plate tectonics, and the climatic change.

There are a number of plates on which the continental land masses of the Earth are carried about. These are constantly moving across the surface of the planet, propelled by areas of upwelling in the centres of the large oceans. When a slow moving land



mass is carried into one of the arid zones about 15°– 30° north and south of the equator, it acquires an arid climate and desert conditons come into existence.

Another effect of plate movement is to create mountain ranges where two plates slowly move into each other. If the two plates are carrying land, where they meet they pile up, slowly raising the surface level. A similar effect occurs when an ocean plate meets a land-carrying plate and is forced below the lighter material of the land-carrying plate, lifting it up.

The effect of a mountain range is to extract water from air passing over it leaving the land beyond dry. Thus as a range slowly builds, the land beyond it gradually dries up.

__The spread of desert__ in areas of vulnerable land are shown by the map. Over-grazing, over-cultivation, poor irrigation and deforestation are primary causes.

__Wind-blown sand__ overtaking a village in Mauritiania, Africa, in 1982 provides an extreme example of desertification. Patches of bare soil are visible in the forest.

There have been times when the average temperature of the Earth has been cooler, during the Ice Ages, and times when it has been warmer and the deserts have advanced or retreated accordingly. But at the present, because man is releasing large amounts of carbon dioxide into the air and clearing vast swathes of vegetation – including the rainforests – some scientists believe that the climate is quickly becoming warmer.

Dust bowl

Raising the overall temperature could have unpredictable effects including extending desert climates to large areas of land, whereas others might become wetter.

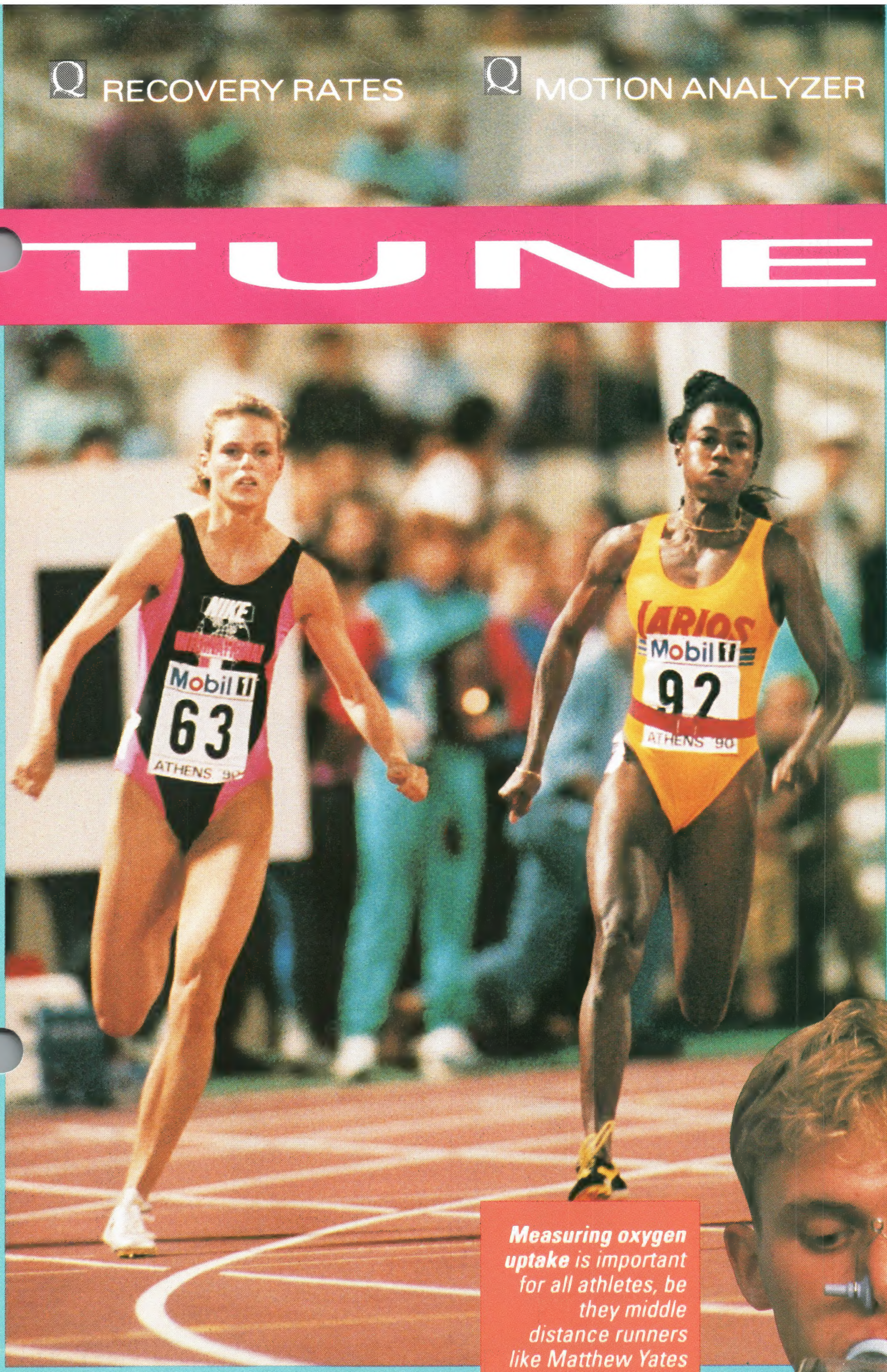
When it comes to stripping areas that were once covered with mixed vegetation so they can be used for mono-culture farming such as wheat growing, there is a great risk of exhausting the soil. The land can become unproductive, vegetation cover fails and if the rains do not fall the soil blows away in the wind. Something similar to this happened in the USA in the 1930s when after a few years the Dust Bowl was created.

Similarly, badly planned irrigation schemes can lead to what are ironically named 'wet deserts'. With poor drainage the soil gets waterlogged as the water table rises. Salt in the soil is brought to the surface, making the ground unfit for growing crops.

In 1994 over 100 nations, concerned about serious land degradation which may affect 30 per cent of the world's land surface, signed the UN International Convention to Combat Desertification.

RECOVERY RATES MOTION ANALYZER FORCE PLATES

TUNE UP



Mike Powell/Allsport

***Measuring oxygen uptake** is important for all athletes, be they middle distance runners like Matthew Yates (UK) or sprinters like Jamaica's Merlene Ottey (above).*

WITH MORE TECHNOLOGY available and a greater understanding of how the body works, today's athletes are increasingly using sports science to help them maximize their potential.

Exercise physiology looks at what is happening within the body – to heart rate, oxygen consumption and muscles – during exercise and in response to training.

Recovery rates

While the athlete exercises in the laboratory on a cycle ergometer (a stationary bicycle) or treadmill (a running conveyor belt about two metres long) the sports scientists take measurements and adjust the difficulty of the exercise. Recovery rates are also measured and sometimes blood analysis is carried out.

Another area, called sports biomechanics, looks at the body in terms of movements. Sports biomechanics addresses questions such as how do springboard divers twist and somersault during flight?

Calculating motion

Very often, activities are filmed at high speeds and from two or three cameras to allow the sports scientist to analyze them in great detail. A machine called a Motion Analyzer is then used to obtain numerical measurements of the exact positions of each part of the athlete's body in every frame of film. The positions are stored in a computer and from them the velocity and acceleration of the whole body and the individual limbs can be calculated throughout the activity.

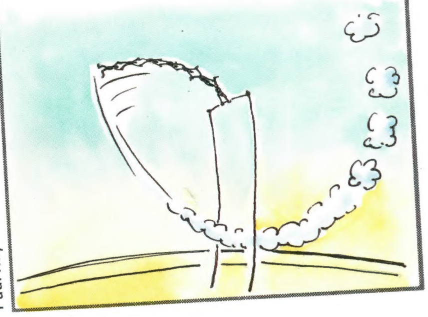
It is also possible to record the forces exerted on the ground by athletes performing various skills. The force plate is a special metal plate fixed into the ground with its top surface level with the floor or track. When connected to a computer it enables records of the forces exerted both ver-

Gray Mortimore Allsport

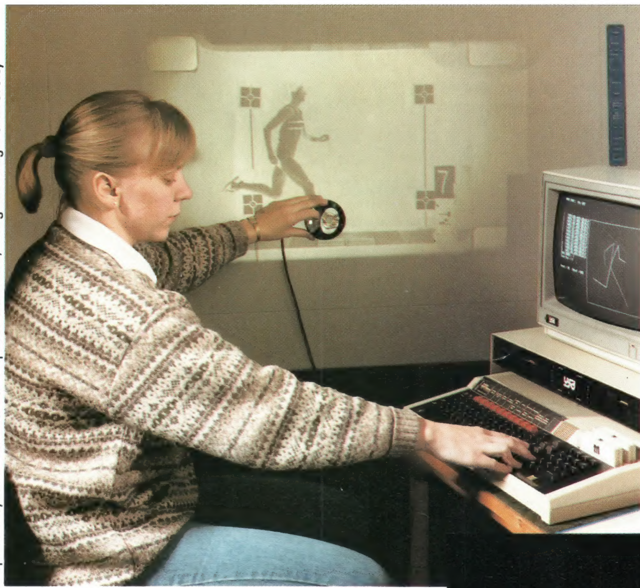
Just amazing!

HANGING HEAVY

WHEN OLYMPIC GYMNASTS SWING AROUND THE HIGH BAR ON ONE HAND, THEY HAVE TO WITHSTAND A GRAVITATIONAL PULL OF 7 G - THE SAME AS BEING WEIGHED DOWN BY SEVEN MEN.



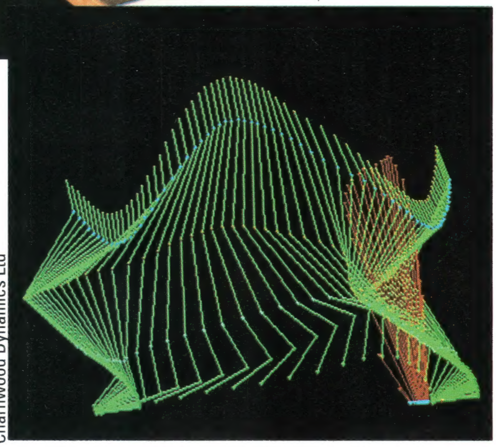
Paul Raymonde



Dept of Physical Education &Sports Science, Loughborough University

A motion analyzer *uses a disc-shaped cursor on an electronic screen to convert film images into data from which to work out acceleration.*

In the CODA *system, a single jump becomes a display of stick figures, and the force applied to the ground, red lines.*



Charnwood Dynamics Ltd

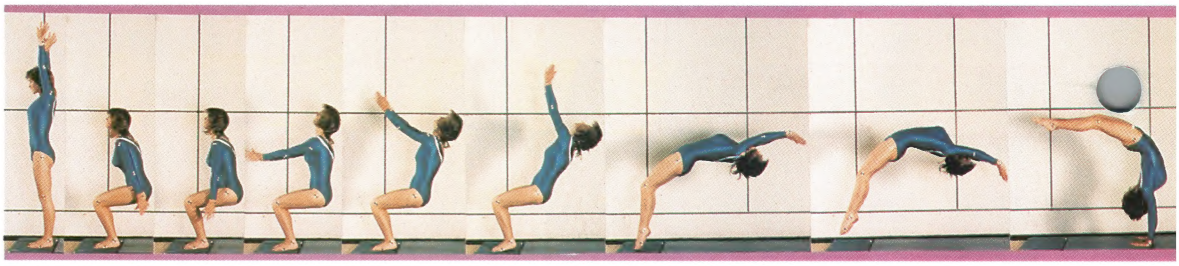
tically and horizontally to be made.

Staff working at Loughborough University, UK, which has a department specializing in sports science, have developed a machine called a CODA. Glass prisms are attached to an athlete's body at important points, such as the ankle, knee, hip and shoulder joints and the computerized system records their positions while performing his or her particular activity. This data can then be used to calculate velocities and accelerations. This is similar to using film analysis but it gives the position information in real time – while the athlete is moving.

Coaching

In some instances, coaching now involves biomechanics. Film taken at major championships is analyzed and the information obtained given back to coaches and athletes to assist them in training for future competitions.

A force plate *analyses the size, direction and point of application of the force exerted by this gymnast as she jumps into a backward handspring.*



INTO THE FUTURE

THE PERFECT ATHLETE

Dept of Physical Education &Sports Science, Loughborough University

Joe Lawrence

▲ The athlete's body is scanned using X-ray tomography. Details of muscle development, body fat and weight are digitized and fed into a computer.

▲ The computer compares the athlete's body details with a record of the optimum characteristics for the athlete's bone structure and chosen sport.

▲ A machine connected to the computer feeds impulses to the athlete's body and limbs, stimulating the muscles into action for optimum exercise during each session.